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Midscale Analysis of Streamside Characteristics in the Upper Grande Ronde Subbasin, Northeastern Oregon

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Abstract

Riparian or streamside areas are the focus of considerable management and public interest in the interior Northwest. Unfortunately, the vegetation and geomorphic characteristics of streamside areas are difficult to assess across large landscapes because streamside areas are geographically small in much of the arid interior. However, managers and scientists need methods to assess streamside conditions across large landscapes for land management planning, watershed analysis, and landscape simulation modeling. We present proposed methods for characterizing streamside vegetation and topography by using geographic information systems, terrain models, and photo-interpreted vegetation maps. We propose application of resulting information for restoration planning and linkage to landscape wildlife and aquatic habitat models in the upper Grande Ronde subbasin of northeastern Oregon.

Introduction

Riparian areas are "plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctively different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland" (USFWS 1997). They influence water quality and aquatic habitat by providing shade, nutrients, sediment, structural material (e.g., logs), and in many other ways (e.g., Cummins et al. 1984, Gregory 1997, Gregory et al. 1991, Platts 1983, Swanson et al. 1982). Riparian vegetation provides important habitat for various terrestrial species (Kauffman et al. 2001, Marcot et al. 1997, Wisdom et al. 2000). Managing forest and rangeland riparian vegetation often affects terrestrial, riparian, and aquatic habitat and ecological processes (Gregory 1997).

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Livestock grazing can alter bank stability (Platts 1983). Streamside roads may constrict stream channels, change channel morphology, and introduce sediment (Beschta 1978, Gregory 1997). Wildfire may generate sediment pulses, decrease shading, increase nutrient inputs, and have other ecological effects on riparian areas (Agee 1993, McNabb and Swanson 1990, Swanson 1981). Riparian and streamside areas in eastern Oregon and Washington have experienced profound change in many areas as a result of recent human activities and other factors (e.g., McIntosh et al. 1994, Wissmar et al. 1994).

Several studies describe streamside and riparian characteristics in northeastern Oregon (Bohle 1994, Case 1995, Crowe and Clausnitzer 1997, Dwire 2001, Lytjen 1998, Otting 1999). Unfortunately, management effects on riparian characteristics are difficult to examine across large landscapes[2] because riparian areas are geographically minor parts of most inland landscapes and are highly variable in space and time. For example, Hann et al. (1997) could not summarize changes in riparian cover types for the interior Columbia basin because of analysis scale limitations. However, Marcot et al. (1997) estimated that primary habitat for 71 vertebrate species in the basin was in aquatic-riparian environments. Wisdom et al. (2000) described source habitats for 91 terrestrial species of concern in the basin but could not assess source habitats for more than 80 additional species, mostly dependent on aquatic and riparian habitats, because the habitat patches were smaller than 100 ha. In addition, delineation of riparian or streamside characteristics across large landscapes may poorly represent actual, fine-scale streamside conditions because of the use of broad-brush assumptions. For example, current direction for managing streamside areas on USDA Forest Service-administered lands in the inland Northwest assumes that most important riparian functions and processes occur within a fixed distance from the channel edge, indicated by one or two times the height of tall trees (USDA FS 1995, USDA and USDI 1995). Although such assumptions may be necessary, given the difficulty of delineating riparian areas across large landscapes, they may not well represent wide variation in riparian spatial extent, as it varies with geomorphology, hydrology, vegetation, and other factors (Swanson et al. 1982).

The most common, and simplest, strategy for riparian management is to protect fixed-width buffers along streams with strict limitations on management within those buffers (e.g., Bren 1995, USDA FS 1995, USDA and USDI 1995). However, fixed-width buffers often do not account for variable-width influences, such as shading, sedimentation, and woody debris input, and may have little relation to landforms and soil characteristics (Hann et al. 1997). The spatial extent of riparian influences is determined by variable attributes of soil, vegetation, valley floor morphology, upstream characteristics, and other factors. Fixed-width buffers tend to become fixed land allocations whether or not they effectively address riparian characteristics.

The Interior Northwest Landscape Analysis System (INLAS) project (Barbour et al. 2001) offers a suite of analytical tools designed to provide information on key forest and range policy questions in the interior Northwest. It consists of models and information tools that span from broad to fine scales. The INLAS effort will include characterization of streamside vegetation and build tools that depict the effects of management and disturbances on streamside vegetation across the upper Grande Ronde subbasin (UGR) in

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[2] Large landscapes are drainage basins of a million ha or larger. Intermediate- or mid-scale landscapes cover subbasins to subwatersheds (tens of thousands to millions of ha). Fine-scale analyses include subwatersheds to individual vegetation stands (tens of ha to tens of thousands of ha).

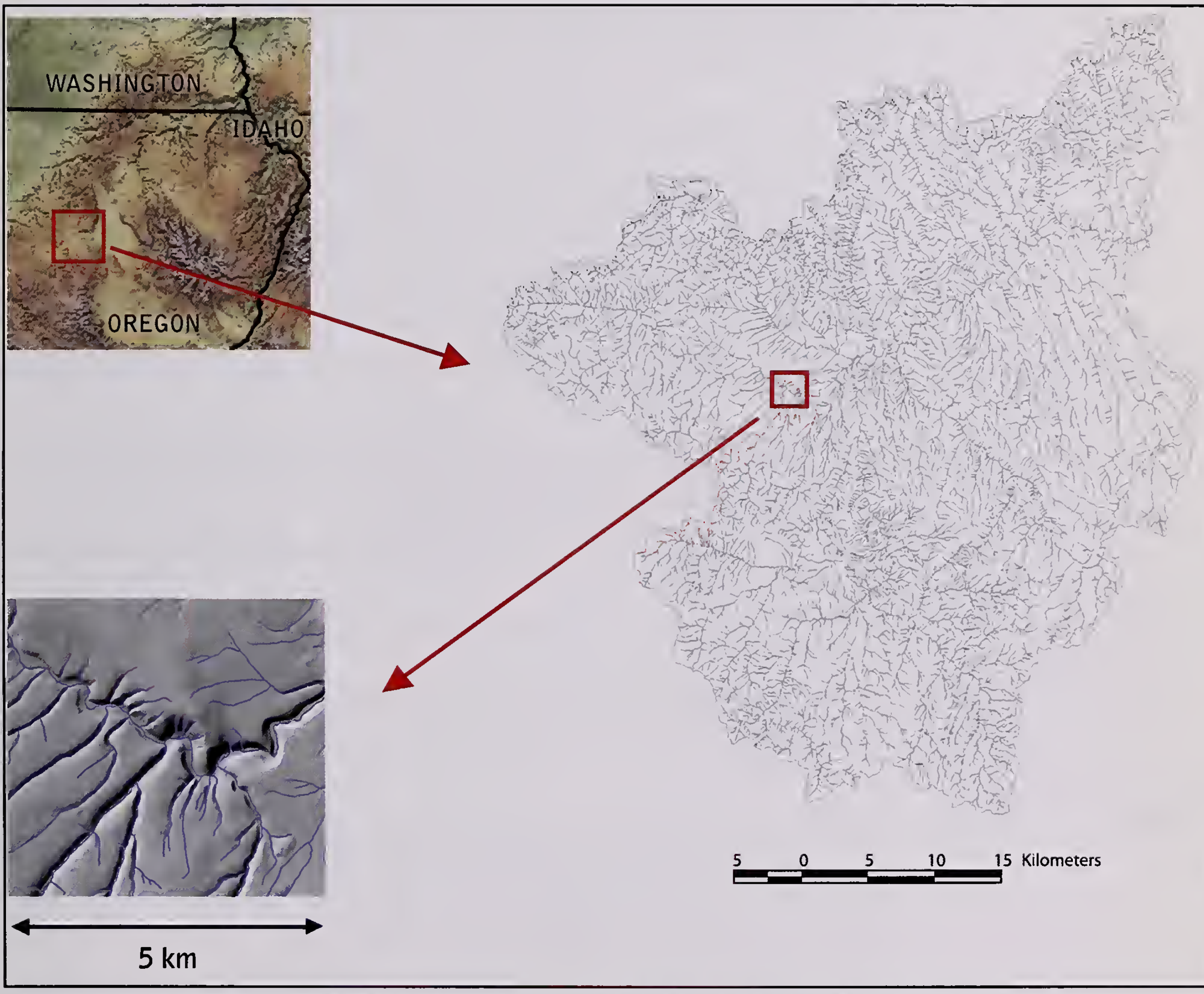

Figure 1—The upper Grande Ronde subbasin (approximately 178 000 ha) analysis area in northeastern Oregon.

northeastern Oregon (fig. 1). We describe methods to build delineation tools and initial applications for characterizing and comparing streamside characteristics across large landscapes while considering potential links to aquatic and terrestrial habitat characteristics. Analysis and characterization of riparian or streamside characteristics at fine scales will require a different set of methods, which we do not discuss. Our methods do not necessarily distinguish streamside vegetation characteristics that differ from those of adjacent uplands. Consequently, we prefer the term "streamside" to "riparian" for our methods, implying a spatial and geomorphic relation to streams, lakes, or drainage ways without requiring vegetative differentiation (e.g., USFWS 1997). Connection of geomorphic and vegetative characteristics to other fluvial processes or characteristics will occur through a linkage to the INLAS aquatic module (Wondzell and Howell 2001).

Research Questions

How can managers and researchers delineate and characterize the vegetation and geomorphic attributes of streamside zones in the UGR landscape while accounting for their variable width? Which watersheds in a large landscape contain streamside areas that

are highly sensitive to disturbance or provide the greatest opportunities for streamside restoration? How can streamside characteristics be incorporated into models of aquatic and terrestrial habitat in the UGR landscape through linkage to other INLAS modules?

Approach

The INLAS analysis will estimate vegetation and geomorphic attributes in streamside areas across watersheds and subbasins by using geographic information system (GIS) modeling techniques, aerial photograph interpretation, and field information. The emphases will be to (1) develop methods to map streamside characteristics across large landscapes, (2) link streamside vegetation and disturbances (e.g., management, fire, and insect and disease activity) to upland vegetation and disturbances, and (3) provide information on streamside characteristics for use in aquatic and terrestrial habitat models (Wales and Suring 2001, Wondzell and Howell 2001).

Expected Outputs

The integration of topographic modeling, stream morphology modeling, and vegetation maps will produce the following:

1. Maps of streamside zones along stream networks in the UGR subbasin that describe valley floor morphology and general vegetative structure (e.g., grass/forb, shrub, deciduous forest, coniferous forest).
2. Characterizations of subwatersheds in the UGR by valley, stream, and streamside vegetation types.
3. Refinements of streamside vegetation maps for inclusion in landscape vegetation models.
4. Links to other INLAS modules: aquatic, terrestrial wildlife, and terrestrial vegetation.
5. Methods that can be easily transferred to analyses of other midscale and larger landscapes.

Methods

Methods will combine GIS modeling, remote sensing, and field sampling. The GIS modeling will be used to produce classes of channel gradient and sinuosity aligned with the Level I valley morphology and stream classification described by Rosgen (1996) (table 1). Rosgen's (1996) Level I classification uses valley width, channel sinuosity, channel gradient, and channel entrenchment from aerial photographs and topographic maps. The digital elevation data (10-m digital elevation models or DEMs) and stream network data (1:24000 stream network maps) available for our analysis are not detailed enough to reveal channel entrenchment or width-to-depth ratio. Our resulting classes, although analogous to Rosgen's Level I classes, will not explicitly include entrenchment and can be viewed as approximations to Level I classes (table 2, fig. 2). An accuracy assessment of 191 randomly generated points from earlier work in the adjacent upper Middle Fork John Day subbasin indicates reasonable agreement between modeled and manually interpreted channel classification, especially in higher gradient and lower sinuosity streams (table 3). Underestimation of lower gradient and higher sinuosity stream channels probably reflects limitations of resolution of the 10-m DEM and stream channel map data available for automated classification.

The GIS modeling will be used to estimate streamside area maps. In this case, the degree of influence the adjacent topographic and vegetative features might have on streams is assumed to be related to the "cost" of transporting materials between the channel and surrounding terrain (fig. 3). Strager et al. (2000) used a GIS process that calculates a "path distance" from the channel to upslope grid cells as a function of vertical and horizontal distance. The result is a "cost" grid or pixel map that depicts the "cost" of moving from the channel to upslope pixels (fig. 4).

Table 1—General classification of stream types by sinuosity and gradient

Stream type	General description	Sinuosity[a]	Channel gradient (percentage slope)
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	1–1.1	≥10
A	Steep, entrenched, cascading step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder-dominated channel.	1.0–1.2	4–10
B	Moderately entrenched, moderate gradient, riffle-dominated channel with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.0–1.2	4–10
C	Low gradient, meandering, point-bar, riffle/pool channels with broad, well-defined flood plains.	>1.2	2–3.9
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks	Not defined	<4
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated flood plains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	Highly variable	<0.5
E	Low gradient, meandering riffle/pool channels with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>1.5	<2
F	Entrenched, meandering riffle/pool channel with high width/depth ratio.	>1.4	<2
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	>1.2	2–4

[a] Stream channel length per unit valley floor length.
Source: Adapted from Rosgen 1996.

Table 2—Definition of stream sinuosity-gradient classes modeled in the upper Grande Ronde subbasin

	Channel gradient (percentage slope)				
Channel sinuosity[a]	<1	1.0—1.7	1.8—4.8	4.9—10.9	>10.9
	Sinuosity-gradient classes[b]				
<1.01	C	B/C	B	A	A
1.01—1.09	C	B/C	B	A	A
1.1—1.19	C	C	C/E	A	B
1.2—1.39	C	E	E	B	NA[c]
>1.39	E	NA	NA	NA	NA

[a] Stream channel length per unit valley floor length.
[b] See table 1 for description of codes.
[c] NA: no channels in a particular class were modeled in the study area.

Table 3—Comparison of modeled and manually classified stream sinuosity-gradient classes for streams nearest to 191 randomly generated points, Middle Fork John Day area, Oregon

	Manual sinuosity-gradient classes[a]						
Automated sinuosity gradient classes[a]	A	B	B/C	C	C/E	E	Total
	Number of points						
A	43	42	1	4	4	3	97
B	19	14	6	3	2	8	52
B/C	0	4	0	0	2	0	6
C	0	1	0	17	1	1	20
C/E	2	4	1	3	1	5	16
E	0	0	0	0	0	0	0
Total	64	65	8	27	10	17	191

[a] See table 1 for description of codes.

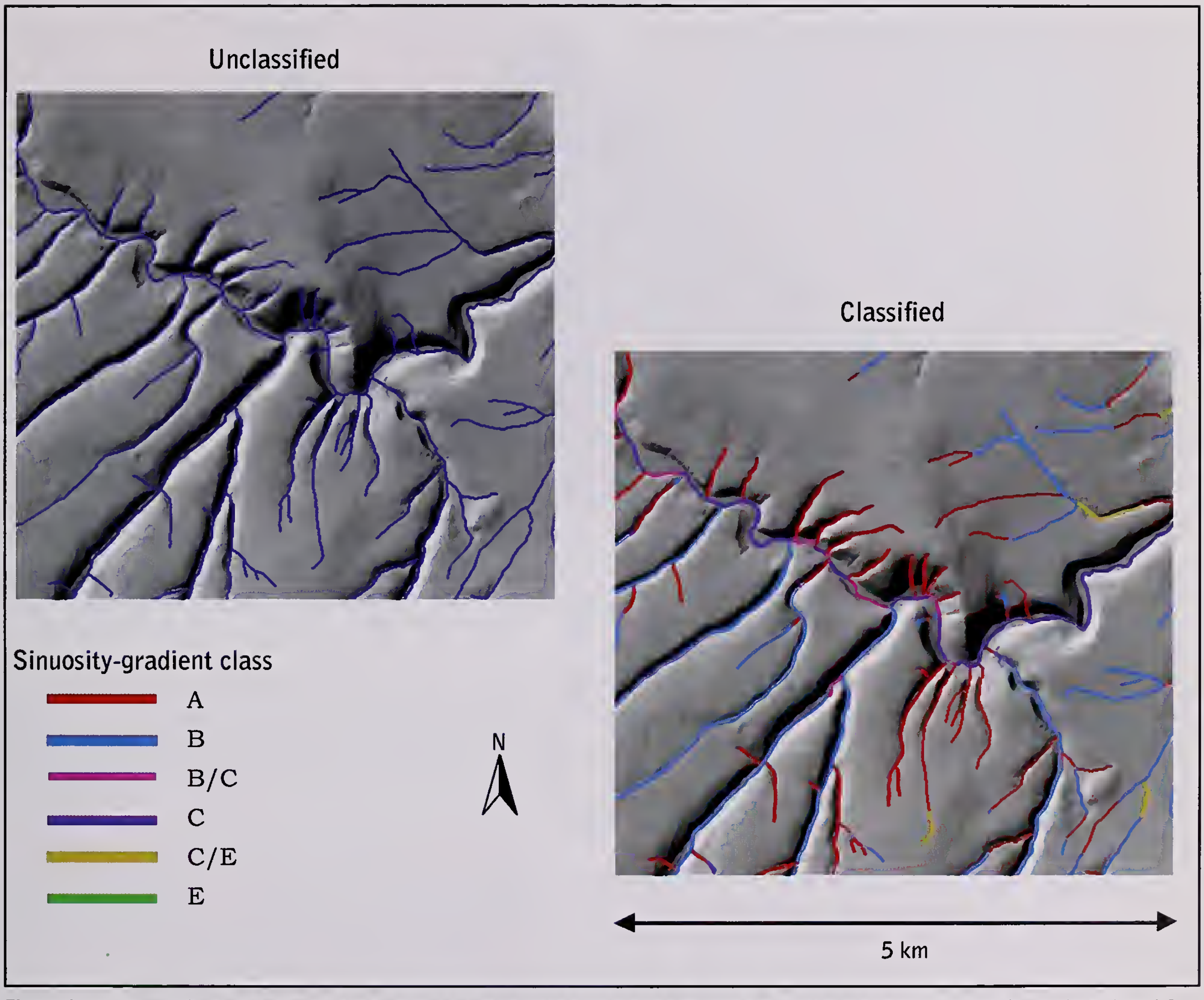

Figure 2—Modeled channel sinuosity-gradient classes in a portion of the upper Grande Ronde subbasin, Oregon (see tables 1 and 2 for code descriptions).

The relative effect of different parts of the valley topography can be scaled to represent different kinds of streamside influences by adjusting the cost function and reclassifying categories of cost. The result is a grid map that shows areas that are potentially streamside given a particular cost function. Initial results indicate considerable expansion of streamside influences in gentle-relief headwater areas. Some of these occur on basalt plateaus, where they may be seasonally moist, extremely shallow-relief, headwater areas. Others historically may have been wet meadows (e.g., before beaver were largely removed), but may not be currently functioning as riparian areas or wet meadows owing to downcutting of channels, simplification of channels, irrigation withdrawals, or other changes that lowered water tables. The GIS process can be calibrated to eliminate much of the headwater streamside influence area, possibly a more realistic representation of current streamside or wet meadow characteristics (fig. 5). Field examination might reveal the current and historical characteristics of these headwater

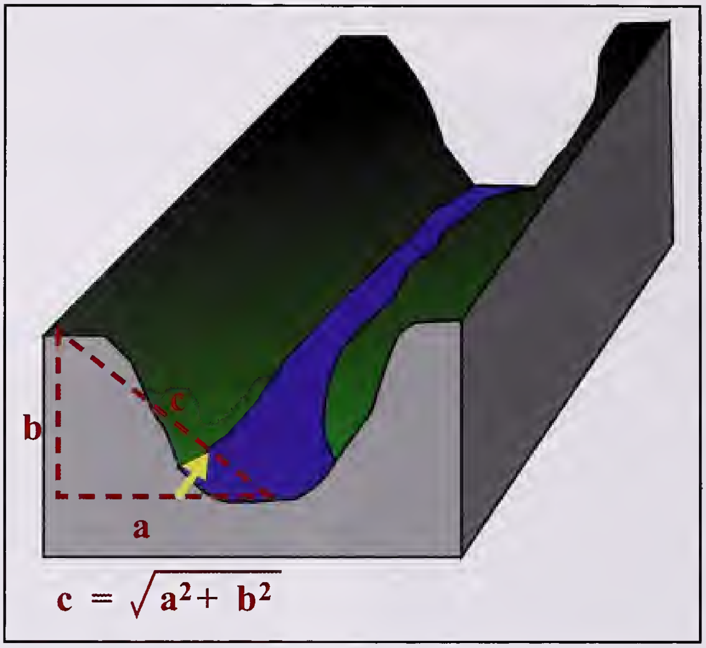

Figure 3—Schematic diagram for PATHDISTANCE analysis.

areas. We will generate valley floor polygons from the grid-cell-based GIS path distance analysis by calibrating calculations based upon a randomly chosen set of cross-valley transects that measure the slope break between valley bottoms and adjacent hill slopes. We will then segment valley floor polygons by channel sinuosity and gradient class to generate a coverage of geomorphically distinct valley floor polygons without regard to vegetation (fig. 6).

Finally, streamside vegetation characteristics will be added by overlaying remotely sensed (satellite or aerial photograph interpretation) vegetation cover type and structure onto streamside areas (fig. 7). Vegetation will be classified according to U.S. Fish and Wildlife Service National Wetlands Inventory methods (USFWS 1997) at the level of dominance types where data are available. The intent is to depict existing (rather than potential) topographic and vegetation characteristics of streamside areas. The major issue to be resolved is the fine-scale mosaic nature of riparian areas and vegetation, often a few meters in width, and the relatively coarse footprint of many remote sensing platforms (Muller 1997). For example, 30-m Landsat-TM pixels may not be adequate to differentiate streamside vegetation types (Muller 1997).

Test and Validate Model and Map Projections

Our intent is to test model and map projections by using a sampling process that combines fine-scale remotely sensed information and, as necessary, field data. Validation and testing might be done as follows: First, a set of uniformly spaced points would be automatically generated for the study area (fig. 8). Although point spacing will need adjustment, 100-m separation may be a good starting point. Each point could be the center of 10-m radius samples. Second, fine-scale imagery (digital camera, satellite imagery, digital orthophotos, radar imagery, high-resolution aerial photographs, etc.) could be acquired for a random selection of these potential samples. The vegetation cover and structure could be interpreted for each sample in broad categories (e.g., coniferous forest, mixed forest, dry shrub, etc.), as it is unlikely that plant species or fine structural data could be acquired. Third, a portion (e.g., approximately 25 percent,

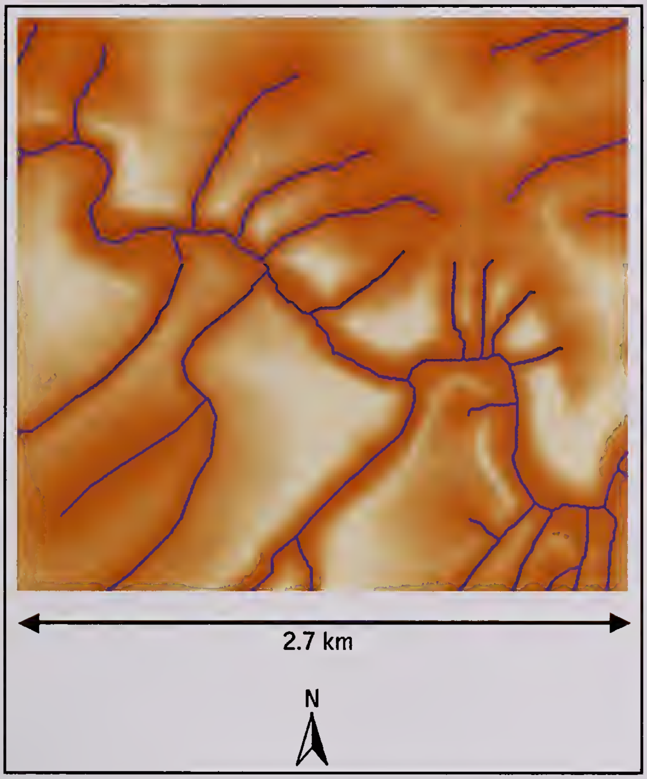

Figure 4—PATHDISTANCE analysis of streamside geomorphology. Darker orange indicates lower "cost" from center of stream based on elevation gain and horizontal distance.

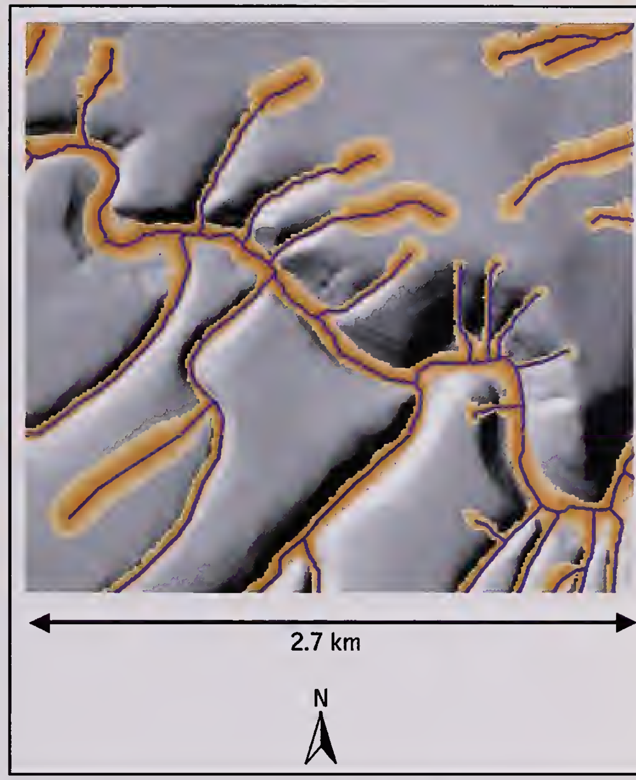

Figure 5—Increased headwater streamside effect in PATHDISTANCE analysis of streamside areas in a portion of the upper Grande Ronde subbasin, Oregon.

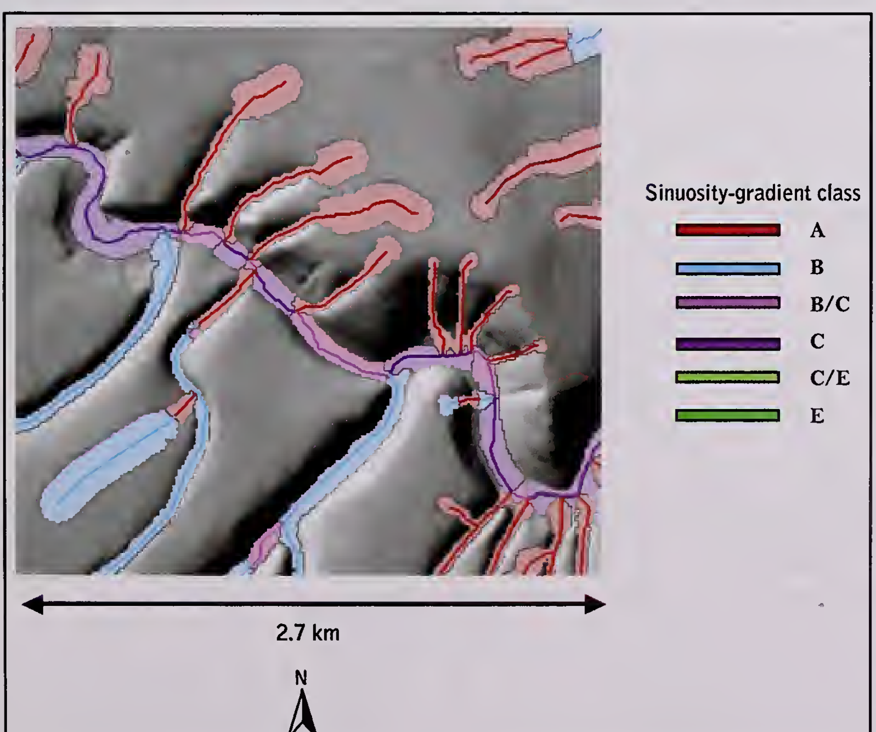

Figure 6—Modeled valley floors with sinuosity-gradient classes assigned in a portion of the upper Grande Ronde subbasin, Oregon (see tables 1 and 2 for code descriptions).

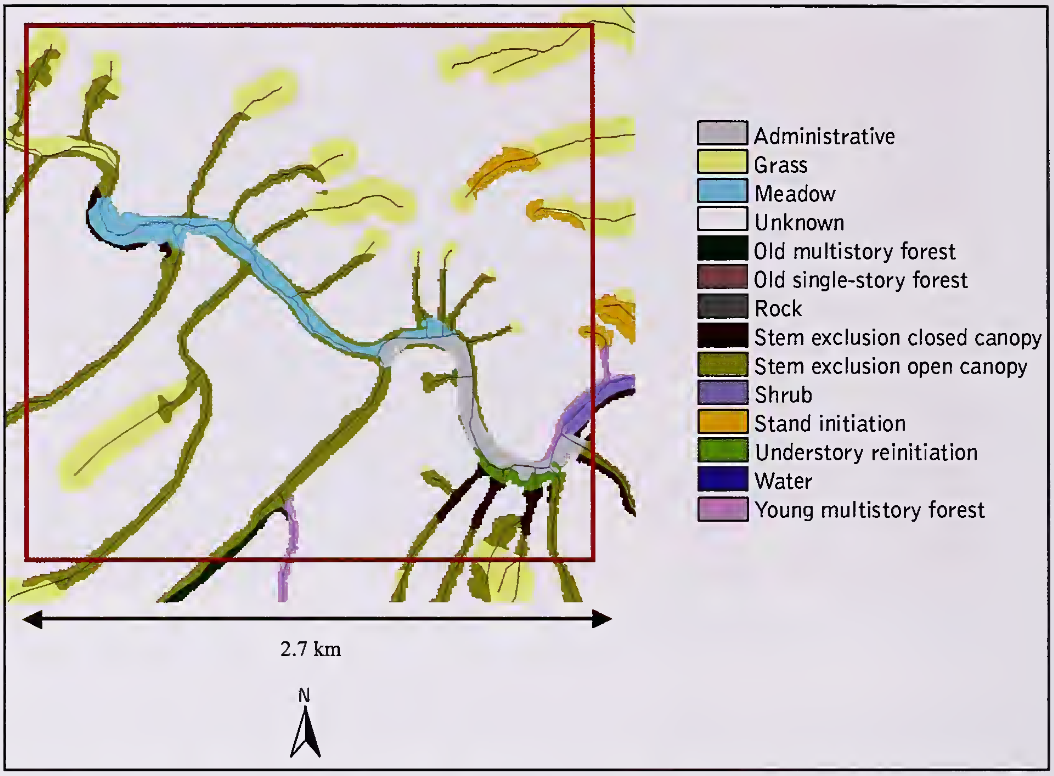

Figure 7—Modeled valley floors with vegetation classes in a portion of the upper Grande Ronde subbasin, Oregon.

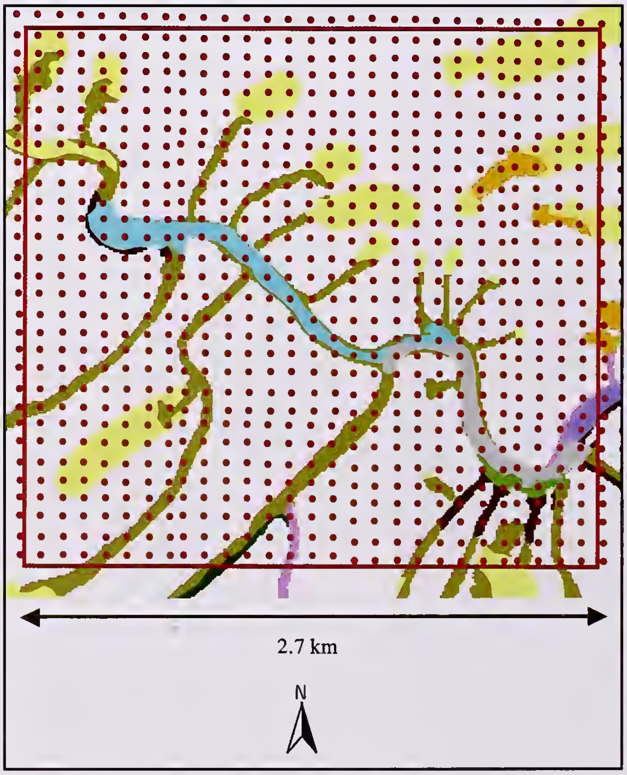

Figure 8—Hypothetical grid of evenly spaced sample areas for field testing valley floor model and vegetation classes.

depending on required sample size) of the samples might be reserved for accuracy assessment, and the remainder would be used to refine cover and structure estimates. Field data (plots) might be taken at a subsample of sites to validate and train image interpretation. The testing and validation portion of the INLAS riparian module is not currently funded.

Develop Midscale Relations Between Environment and Potential Streamside Vegetation

The U.S. Department of Agriculture, Forest Service, Pacific Northwest Region has a set of fine-scale riparian plot data for the UGR and Blue Mountains province (Crowe and Clausnitzer 1997). The relations between fine-scale riparian characteristics and valley morphology types for the Blue Mountains area will be examined by using these data. The intent of such an analysis will be to examine the relation between vegetative classes and midscale environmental features (geomorphic valley classes, elevation, geographic area, etc.) with the hope of predicting potential streamside vegetation types. If successful, the vegetation prediction tools will produce generalized estimates of potential streamside vegetation and allow summarization of streamside potential vegetation by valley floor type in the UGR (fig. 9).

Apply Midscale Riparian Analysis to Other Areas in the Blue Mountains Province

Many areas in the Blue Mountains and the Western United States lack 10-m DEMs and accurate 1:24000 stream layers. Depictions of valley floor class, streamside influence zones, and vegetation may be much less accurate. However, general characteristics of entire watersheds in terms of area by general vegetation class and valley floor type should be indicative of relative differences among watersheds. We plan to develop methods to characterize the streamside settings for other areas in the Blue Mountains province by using these methods. Input data sets will include 10-m or 30-m DEMs, existing vegetation maps, existing stream maps, and predicted potential riparian vegetation. Our methods will allow land managers and others to identify key streamside areas for restoration focus, stratify streamside monitoring by geomorphic and vegetation features, develop descriptions of streamside characteristics for programmatic plans, and better understand underlying streamside potentials for water-quality management plans. In sum, we want to provide ways for land managers and others to characterize and understand streamside characteristics across midscale and larger landscapes.

Link Streamside Characteristics to Wildlife and Aquatic Habitat Models

Wales and Suring (2001) are developing terrestrial wildlife habitat models that project future habitat as a function of vegetation, management activities, disturbances, and other information. Riparian habitats are an important component of terrestrial habitat in the study area. Our analysis will provide information on existing vegetation, potential vegetation, and topographic features in streamside areas for use in terrestrial habitat modeling.

Wondzell and Howell (2001) are constructing a Bayseian Belief Network model that estimates the effects of management activities, disturbances, vegetation, geomorphology, and other landscape features on aquatic habitat characteristics (fig. 10). Many of their model inputs require information about the geomorphic and vegetation characteristics of streamside areas. Our work will produce several of these inputs.

English Equivalents

When you know:	Multiply by:	To find:
Hectares (ha)	2.47	Acres
Meters (m)	3.28	Feet

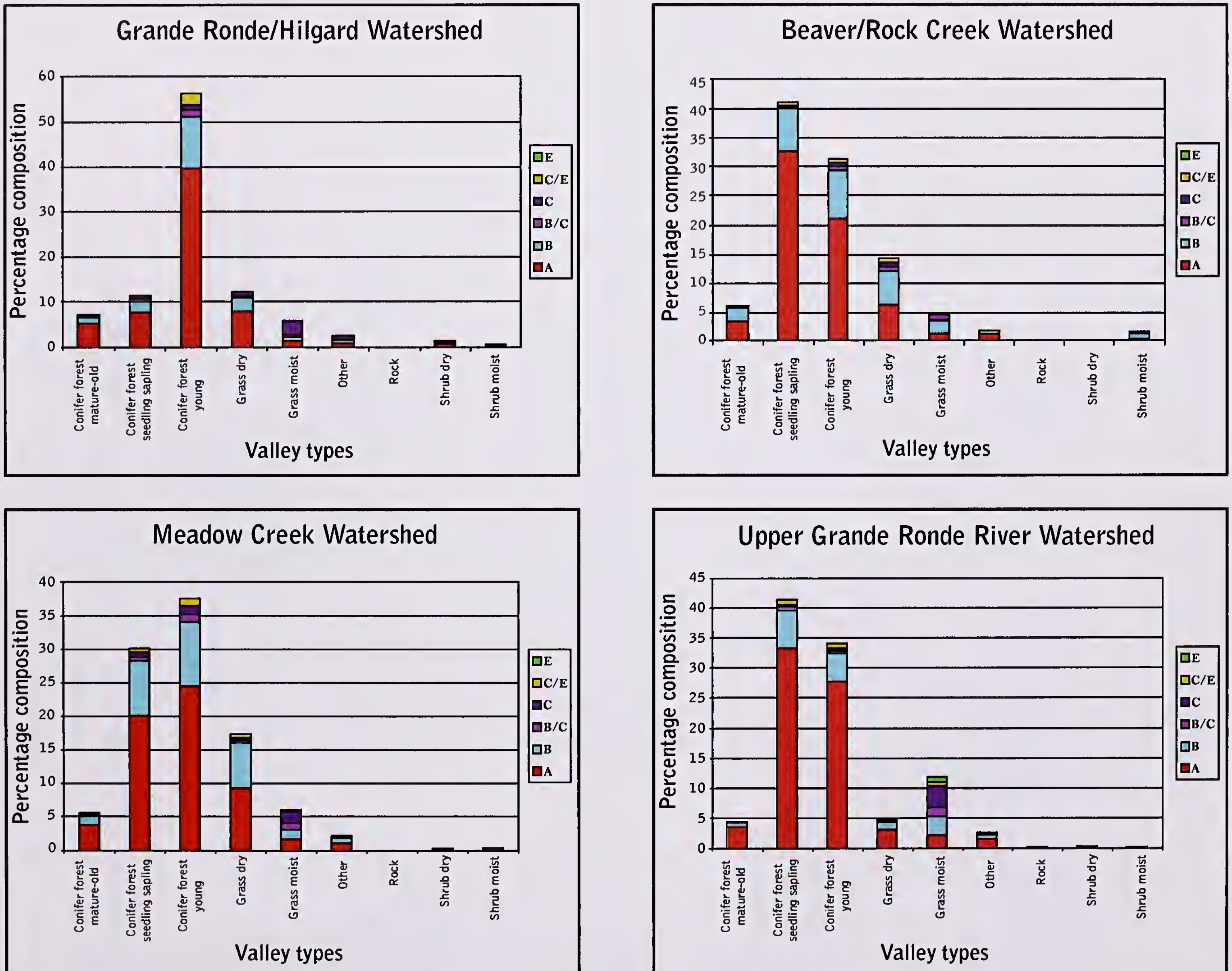

Figure 9—Midscale characterization of existing streamside vegetation and geomorphic characteristics in four watersheds in the upper Grande Ronde subbasin, Oregon.

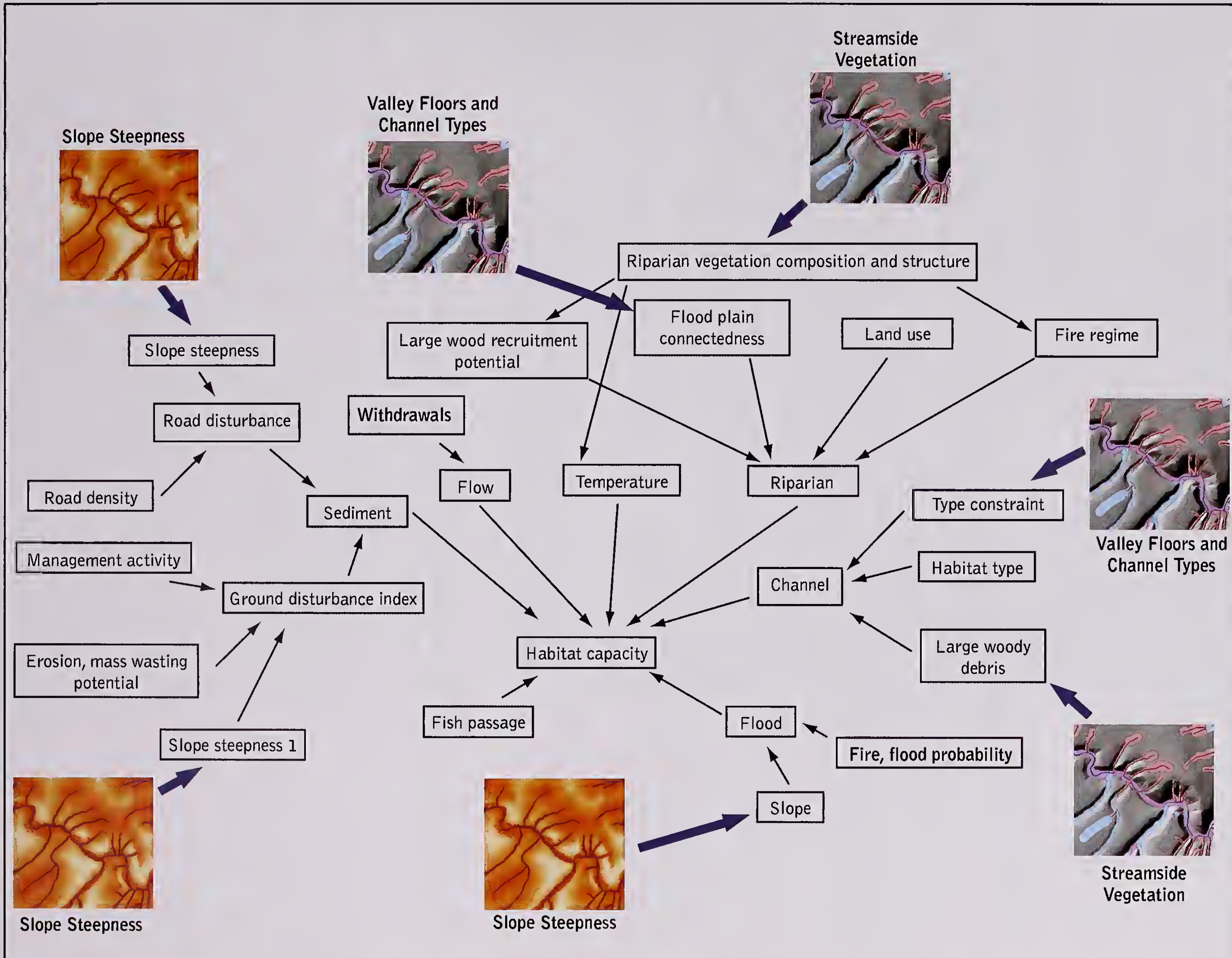

Figure 10—Possible linkage of riparian-streamside module to aquatic module.

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